



# METHOD AND APPARATUS TO FACILITATE INDEPENDENT PROTECTION SWITCHING IN A DISTRIBUTED NETWORK

## Field of the Invention

[0001] The invention relates to networking. More specifically, the invention relates to control and protection switching in a network.

## Background

[0002] Framers are commonly used in networking systems. Frames are used to organize the flow of information over a network line. In the case of Synchronous Optical Network (SONET) frames, each frame may be viewed as carrying "n" synchronous payloads envelopes (SPEs) of 810 bytes. Conceptually, a frame may be thought of as  $SPE_1, SPE_2, \dots, SPE_N$ .

[0003] For SONET frames, the time consumed by each frame corresponds to 125 $\mu$ s regardless of the number of SPEs carried per frame (i.e., "n"). Furthermore, the number of SPEs carried per frame remains constant from frame to frame. Thus, the number of SPEs carried per frame is indicative of the network line speed.

[0004] For example, a SONET networking line having only one SPE per frame (i.e.,  $n=1$ ) corresponds to a line speed of 51.840 Mbs (i.e., 810 bytes every 125 $\mu$ s). Similarly, a SONET networking line having three SPEs per frame (i.e.,  $n=3$ ) corresponds to a line speed of 155.52 Mbs (i.e., 2430 bytes every 125 $\mu$ s), a SONET networking line having forty eight SPEs per frame (i.e.,  $n=48$ ) corresponds to a line speed of 2.488 Gb/s (i.e., 38880 bytes every 125 $\mu$ s), etc.

[0005] One SPE per 125 $\mu$ s is referred to as an STS-1 signal. Thus, a 51.840 Mbs SONET networking line carries a single STS-1 signal; a 155.52 Mbs SONET networking line carries three STS-1 signals; and a 2.488 Gb/s SONET networking line carries forty eight STS-1 signals. Typically, each STS-1 signal may be viewed as corresponding to the same SPE position across different frames. Each STS-1 signal typically has an STS identifier (STS ID) corresponding to a line and relative position in the frame. Note that if the applicable networking line is optical "OC" is typically used instead of "STS" (e.g., OC-3, OC-48, etc.).

[0006] A network line couples a pair of networking systems (e.g., switches, routers, multiplexers, gateways, etc.) so that the pair of networking systems may communicate with one another. Examples of networking lines include fiber optic or copper cable. Networking systems are typically provided with an automatic protection switch (APS) on the line card of the network element to switch signals between a working line and a separately provided protection line in the event of a line failure of the working line. This results in a change of the STS ID corresponding to a particular STS-1. The resulting change must be propagated between line cards in the network such that the protection switch for downstream line cards is dependent on the upstream line cards. For example, when a double failure occurs, the downstream node must be provided the status for both failing lines to allow flows to be properly routed.

005043.P010

STATION	DATE	TIME	WIND	TEMP.	WIND	TEMP.	WIND	TEMP.
1	1911	10	10	10	10	10	10	10
2	1911	10	10	10	10	10	10	10
3	1911	10	10	10	10	10	10	10
4	1911	10	10	10	10	10	10	10
5	1911	10	10	10	10	10	10	10
6	1911	10	10	10	10	10	10	10
7	1911	10	10	10	10	10	10	10
8	1911	10	10	10	10	10	10	10
9	1911	10	10	10	10	10	10	10
10	1911	10	10	10	10	10	10	10
11	1911	10	10	10	10	10	10	10
12	1911	10	10	10	10	10	10	10
13	1911	10	10	10	10	10	10	10
14	1911	10	10	10	10	10	10	10
15	1911	10	10	10	10	10	10	10
16	1911	10	10	10	10	10	10	10
17	1911	10	10	10	10	10	10	10
18	1911	10	10	10	10	10	10	10
19	1911	10	10	10	10	10	10	10
20	1911	10	10	10	10	10	10	10
21	1911	10	10	10	10	10	10	10
22	1911	10	10	10	10	10	10	10
23	1911	10	10	10	10	10	10	10
24	1911	10	10	10	10	10	10	10
25	1911	10	10	10	10	10	10	10
26	1911	10	10	10	10	10	10	10
27	1911	10	10	10	10	10	10	10
28	1911	10	10	10	10	10	10	10
29	1911	10	10	10	10	10	10	10
30	1911	10	10	10	10	10	10	10
31	1911	10	10	10	10	10	10	10
32	1911	10	10	10	10	10	10	10
33	1911	10	10	10	10	10	10	10
34	1911	10	10	10	10	10	10	10
35	1911	10	10	10	10	10	10	10
36	1911	10	10	10	10	10	10	10
37	1911	10	10	10	10	10	10	10
38	1911	10	10	10	10	10	10	10
39	1911	10	10	10	10	10	10	10
40	1911	10	10	10	10	10	10	10
41	1911	10	10	10	10	10	10	10
42	1911	10	10	10	10	10	10	10
43	1911	10	10	10	10	10	10	10
44	1911	10	10	10	10	10	10	10
45	1911	10	10	10	10	10	10	10
46	1911	10	10	10	10	10	10	10
47	1911	10	10	10	10	10	10	10
48	1911	10	10	10	10	10	10	10
49	1911	10	10	10	10	10	10	10
50	1911	10	10	10				

**[0011]** Figure 4 is a flow diagram of backplane operation in one embodiment of the invention.

## DETAILED DESCRIPTION

[0012] **Figure 1** is a block diagram of a line card of one embodiment of the invention. An ingress line 120 from a distributed network comes into line interface 118. Line interface 118 includes an electrical to optical (E/O) and an optical to electrical (O/E) converter. The line interface forwards the incoming signals from ingress line 120 through bus termination unit 116 via bus 114 to a bus interface 112 in the backplane 102 of the line card 100. In one embodiment, the line card 100 is part of a SONET network. In one embodiment, bus 114 may carry signals at a rate from STS-1 to STS-48 to and from the bus interface 112. Bus interface 112 forwards incoming signals to an ingress time slot interchange (ITSI) module 108. The signals are then forwarded on to switch fabric 106 which may perform switching and routing functions on the signals. The switch fabric 106 may also be coupled a serdes (Serializer/Deserializer) interface. The switch fabric is also coupled through a translation module 104, which in one embodiment, may include a cross connect table. Outgoing signals are mapped by the translation unit to a set of logical identifiers corresponding to inputs of an egress time slot interchange unit (ETSI) 110. In some embodiments, the logical IDs are logical STS IDs and the cross connect maps physical STS IDs to the logical STS IDs. The logical identifiers are fixed at initialization of the line card 100. The cross connect table will keep the logical STS IDs unchanged, so the STS numbers transmitted by line 122 are fixed. The appropriately mapped signals are then forwarded by the ETSI 110 back through the bus interface 112 over bus 114 to bus termination unit 116. Line interface 118 performs appropriate conversion as necessary, and the outgoing signals are transmitted on egress line 122.

[0013] **Figure 2** is a schematic diagram of the functionality of the translation module. Physical identifiers for the signals on a number of working lines (designated  $W_x$ ) are provided to the right-hand side of a translation module 104. When a line failure occurs in the physical line corresponding to physical identifiers 202, the physical signals are rerouted onto the protection line (designated P). The protection line physical identifiers 204 are then remapped 206 to correspond to the

mapping 210 of the physical line that failed. Thus, when the signals arrive at the translation module, either on the working line or a protection line, they are mapped to the same logical egress identifier.

[0014] Notably, this remapping method is suitably for implementation of various protection schemes in a wide array of SONET topologies. For example, it may be used in unidirectional path switched rings (UPSR), bi-directional line switched rings (BLSR), as well as 1:n protection and 1+1 protection topologies.

[0015] Figure 3 is a block diagram of a system of one embodiment of the invention. A first node having a plurality of working line  $W_x$  and at least one protection line  $P$  is coupled to a second node 302 and an analogous set of working and protection lines. Where a signal scheduled to come in to a first node 300 on working line  $W_N$  and egress node 300 on working line  $W_2$ , if the line  $W_N$  fails, the signal comes in to the first node 300 on the protection line  $P$ . Where as shown, the ingress of second node 302  $W_1$  line which is coupled to  $W_2$  egress line of the first node 300 fails, rather than routing the signal up to  $W_2$  within the first node 300, the protection line retains the signal, and the signal egresses the first node 300 on protection line  $P_1$ . Where that same signal was scheduled to egress the second node 302 on working line  $W_{N+1}$ , the translation module 104 in second node 302 routes that signal directly to egress  $W_{N+1}$ . For example, in Figure 3,  $W_{N+1}$ 's output is decided by logical STS IDs. When  $W_1$  fails,  $P_1$  will send STS-IDs to  $W_{N+1}$  card. The cross connect table will change, but all logical STS IDs are kept unchanged. Because the output is only related to the logical STS IDs, the output looks unchanged, e.g., as though no line failure had occurred.

[0016] Figure 4 is a flow diagram of backplane operation in one embodiment of the invention. A determination is made at decision block 402 whether a particular incoming line is down. If the line is not down, the physical incoming line is mapped to a corresponding logical ID of an egress input at functional block 404. If the incoming line is down, the protection line is remapped to the egress input corresponding to the down physical line at functional block 406. After the mapping or remapping, the signal is passed to the selected input of the egress time slot

